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VARIATIONAL MULTISCALE LES INVESTIGATION ON THE INFLUENCE OF BOUNDARY LAYER THICKNESS ON THE BASE DRAG AND ON THE NEAR-WAKE FLOW OF AN AXISYMMETRIC BLUNT-BASED BODY

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Summary

The characterization of the dependence of the base pressure of bluff bodies upon the geometrical and fluid dynamical parameters defining a certain configuration is a complex and still open problem. This work is part of an experimental and numerical research activity aimed at characterizing and reducing the base drag of an axisymmetric blunt-based body. It was observed in experiments that the increase of the boundary layer thickness produces a reduction of the base suctions and that this is probably connected with an increase of the length of the mean recirculation region behind the body.

In the present work, the results of a Variational MultiScale (VMS) LES carried out on the same body as in the experiments are presented and analysed. The simulations have been carried out by using AERO, an in-house developed numerical code based on a linearized implicit time advancing and on a mixed finite-volume/finite-element method, applicable to unstructured grids for space discretization.

The axisymmetric model configuration comprises a forebody with a $3:1$ elliptical contour, and a cylindrical main body with a sharp-edged base perpendicular to the axis. The ratio between the diameter, d, and the overall length, l, is $d/l = 0.175$. The Reynolds number based on the freestream velocity and the overall length is $Re = 550000$, as in the experiments. Differences are that simulations can be carried out for laminar freestream conditions, while a freestream turbulence intensity of 0.9% is present in the experiments, and that the effect of the model support is not taken into account.

In the numerical simulations the variation of the boundary layer thickness is obtained by using a free-slip boundary condition over different initial portions of the body surface.

Three different boundary layer thicknesses, measured $0.1d$ from the base contour, are obtained. The results show that the base suctions decrease with increasing boundary layer thickness. This variation is found to be connected with an increase of the length of the mean recirculation region that is present behind the body. These results are also compared with the experimental results and DNS simulations results in order to investigate the connection between boundary layer thickness, near wake flow features and base pressure for different turbulence level of the oncoming flow and different Reynolds numbers.